National Aeronautics and Space Administration
Aeronautics Research Mission Directorate

Aeronautics Test Program

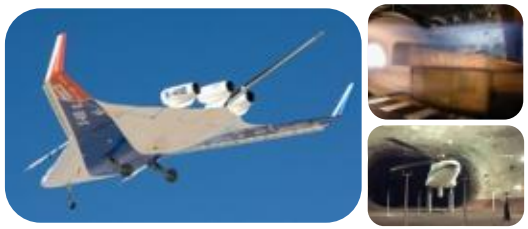
Mike George
Director, Aeronautics Test Program (ATP)

NASA Advisory Committee Review
April 23, 2010 @ LaRC

Outline of Presentation

- Program Overview
- Changing Test Environment and Challenge
- ATP Strategic Plan and Reliance Initiative
- American Recovery and Reinvestment Projects
- Upcoming Tests
- Partnerships

Aeronautics Research Mission Directorate (ARMD)



Fundamental Aeronautics Program

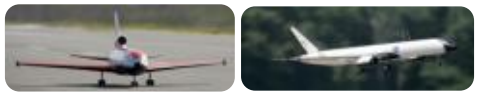
Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

Integrated Systems Research Program

Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment

Airspace Systems Program

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.



Aviation Safety Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.

Aeronautics Test Program

Ensure the continuous availability of a portfolio of NASA-owned ground and flight test capabilities, which are strategically important to meeting national aerospace program goals and requirements

ATP Assets Distributed Across Four Centers

Ames Research Center

Glenn Research Center

Dryden Flight Research Center

Langley Research Center

ATP Assets

AMES RESEARCH CENTER

- Unitary Plan Wind Tunnel

GLENN RESEARCH CENTER

- Icing Research Tunnel
- 10x10 Supersonic Unitary Wind Tunnel
- 8x6 Transonic Wind Tunnel
- 9x15 Low Speed Wind Tunnel
- Propulsion Systems Lab

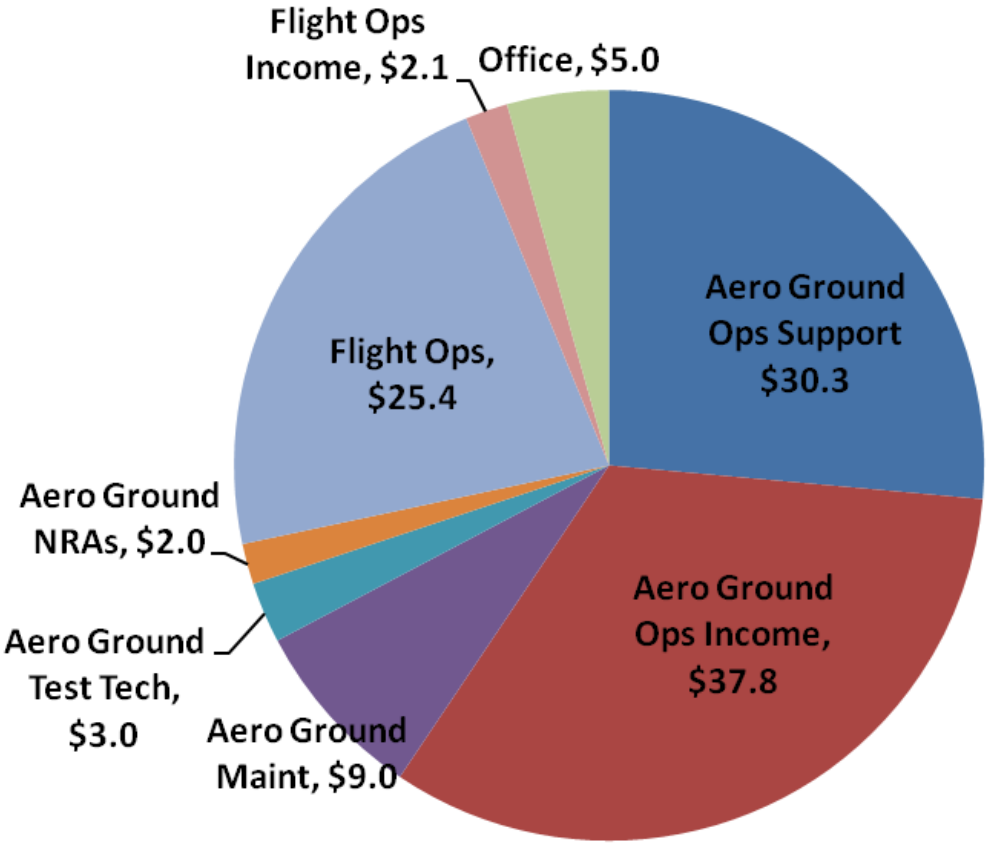
LANGLEY RESEARCH CENTER

- National Transonic Facility
- 8-foot High Temperature Tunnel
- Langley Aerothermodynamics Lab
- 14x22 Subsonic Wind Tunnel
- Transonic Dynamics Tunnel
- 4-foot Supersonic Unitary Tunnel
- 20-foot Vertical Spin Tunnel

DRYDEN FLIGHT RESEARCH CENTER

- Western Area Test Range
- Support Aircraft
- Test Bed Aircraft
- Flight Loads Laboratory
- Research Aircraft Integration Facility

ATP FY2010 Budget Distribution



FY2010 Plan, $114.6M
(ATP = $74.7M, Op Income = $39.9M)

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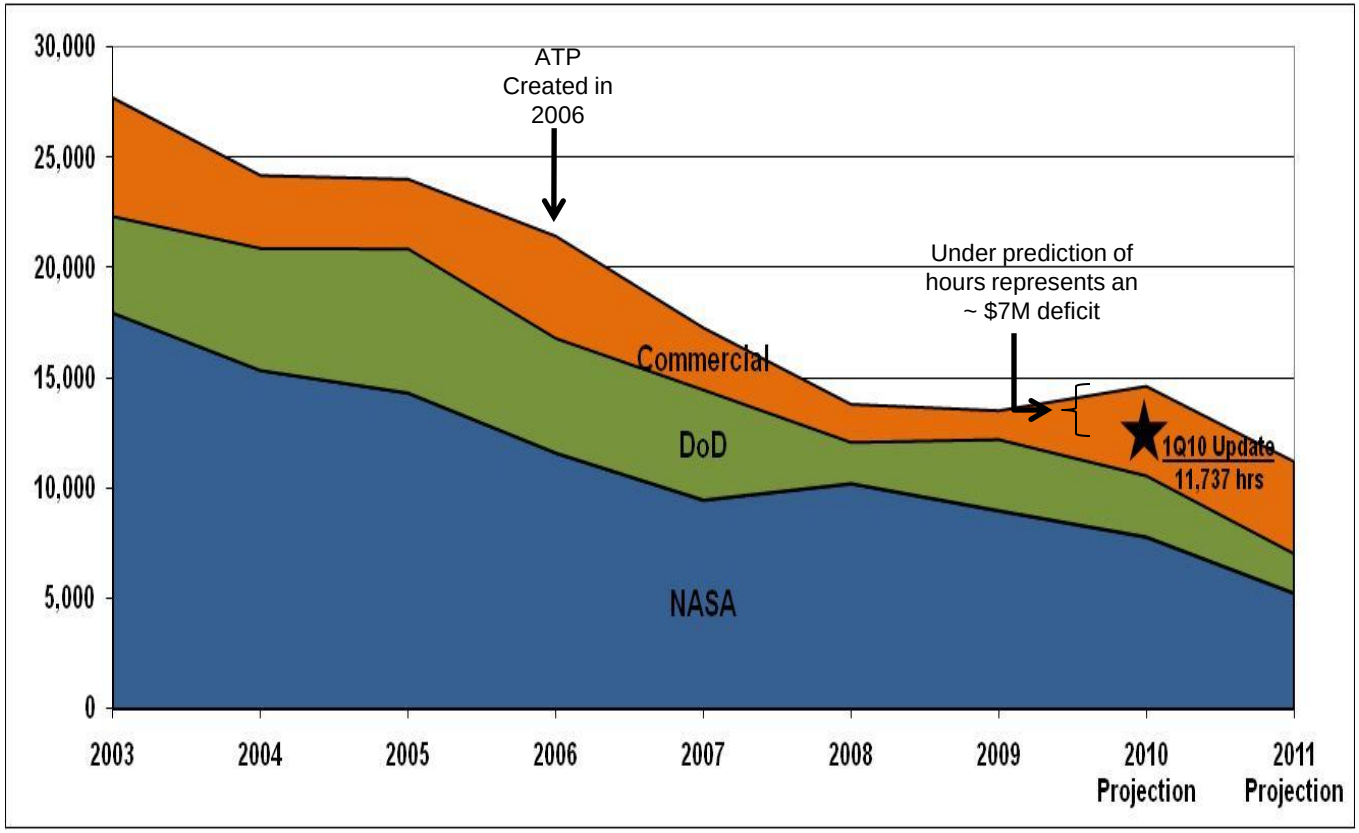
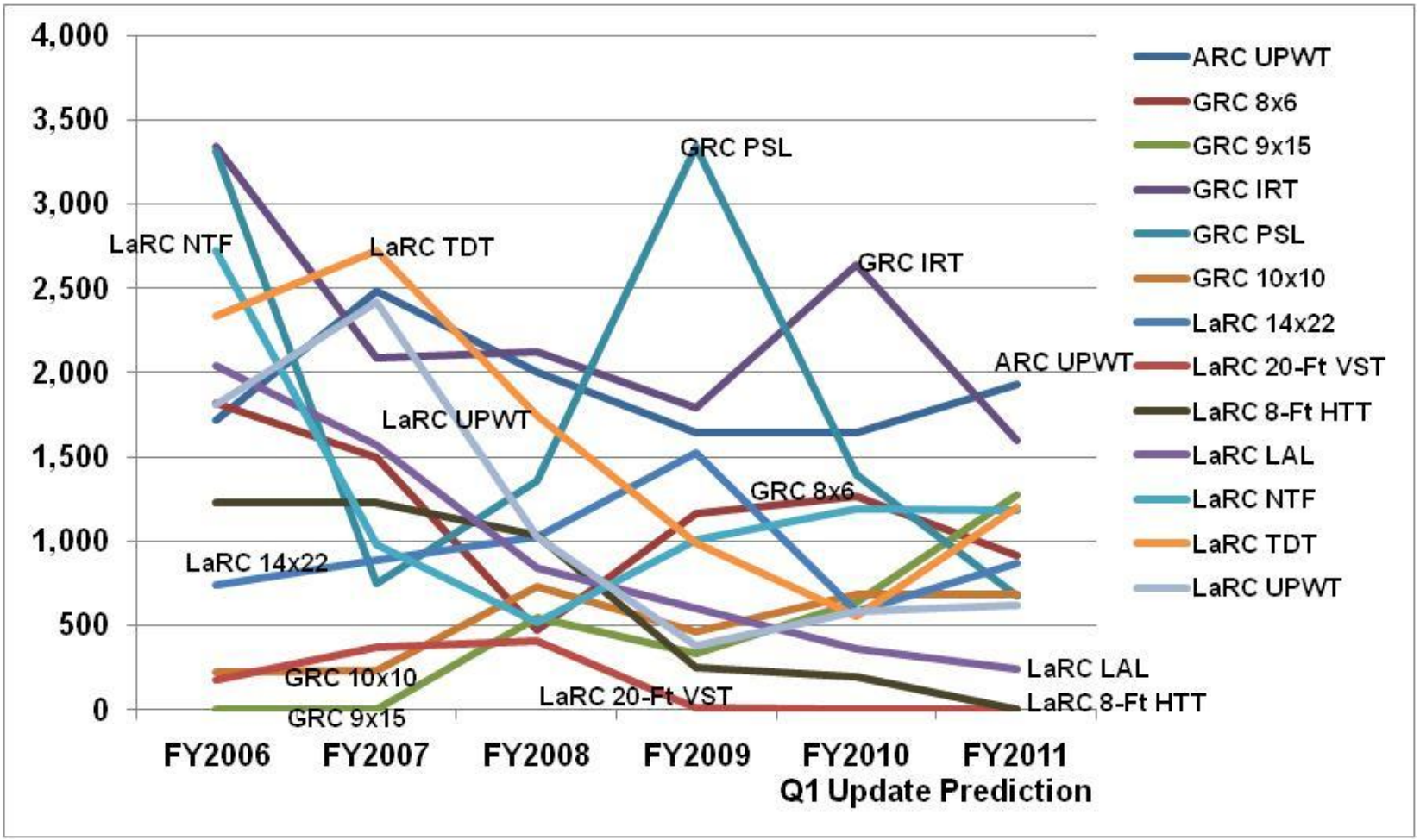
ATP Ground Utilization Trend by User (Hours)

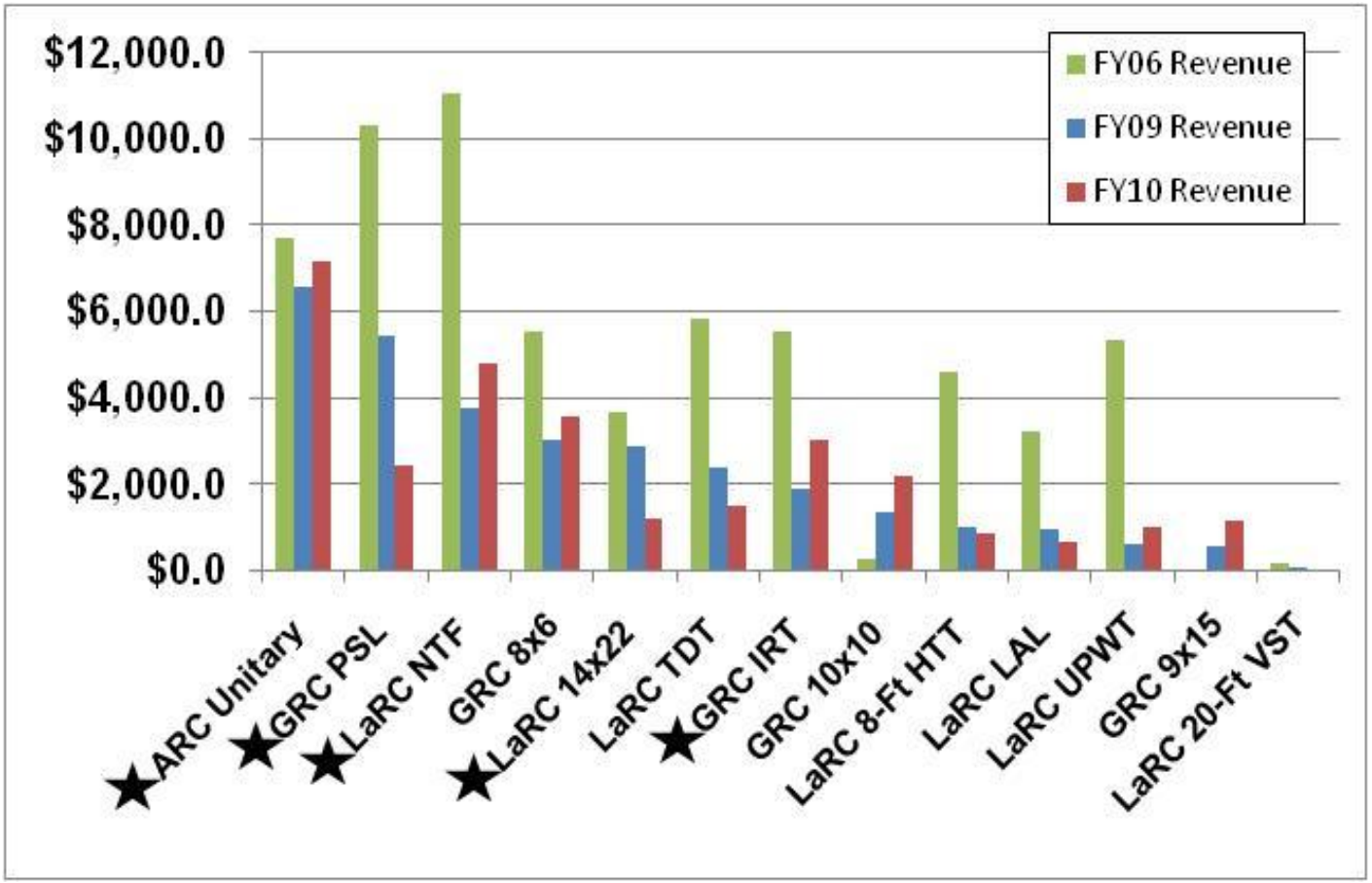


~ 11,000 hour decline in customer usage represents ~ $34M in customer revenue

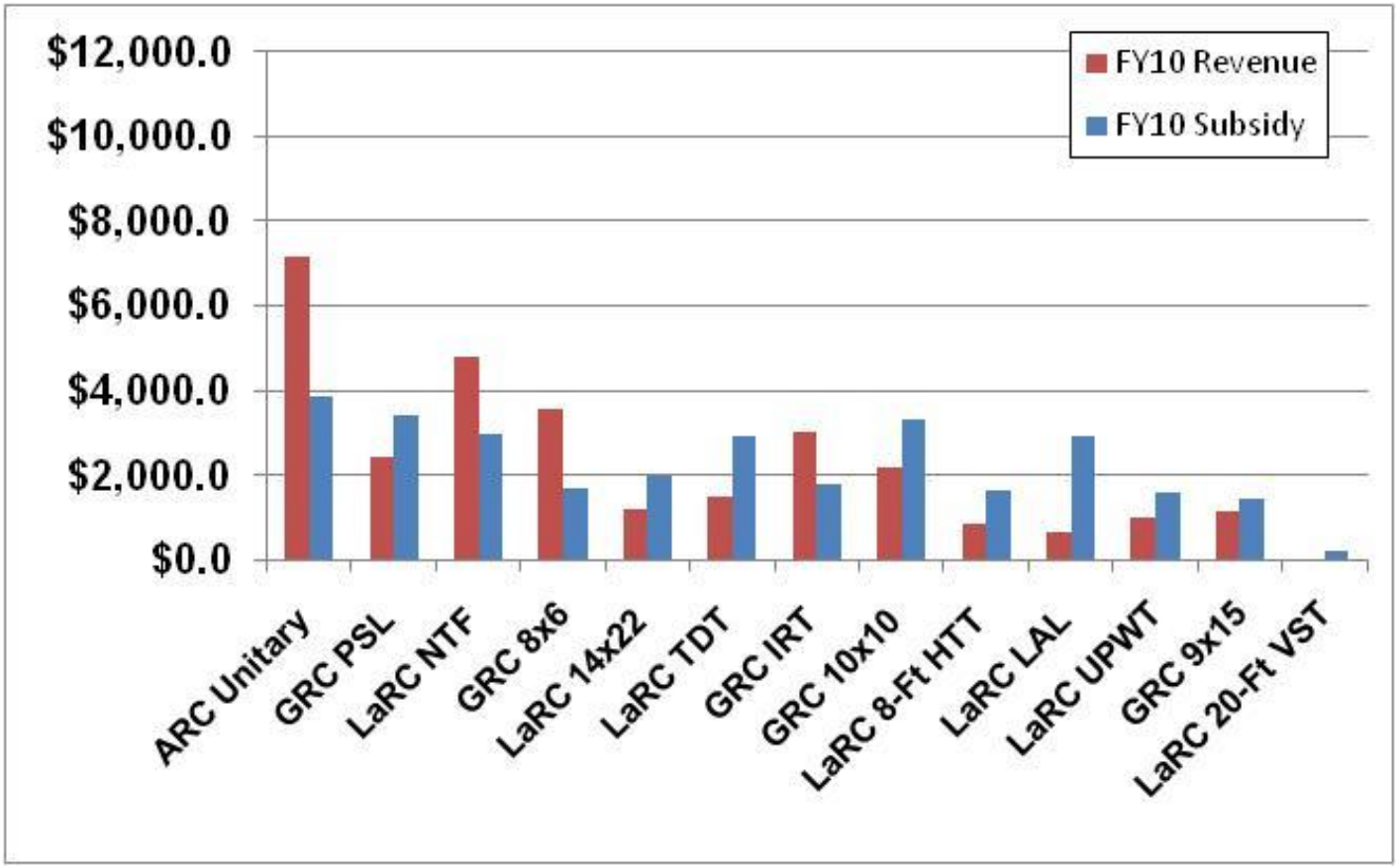
ATP Ground Utilization Trend by Facility (Hours)



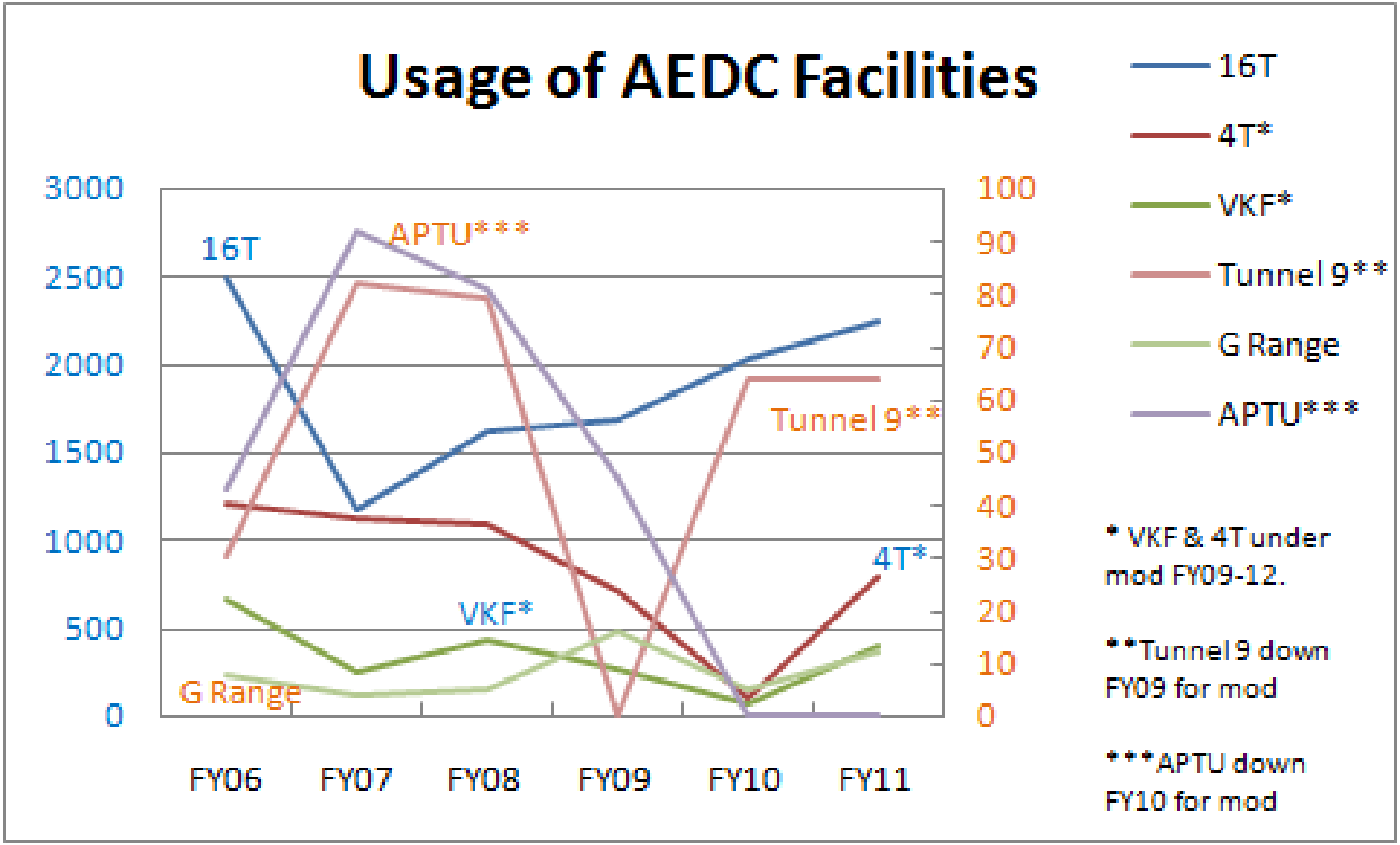
Revenue Trend for ATP Ground Test Facilities



Revenue versus Subsidy for Ground Test Facilities



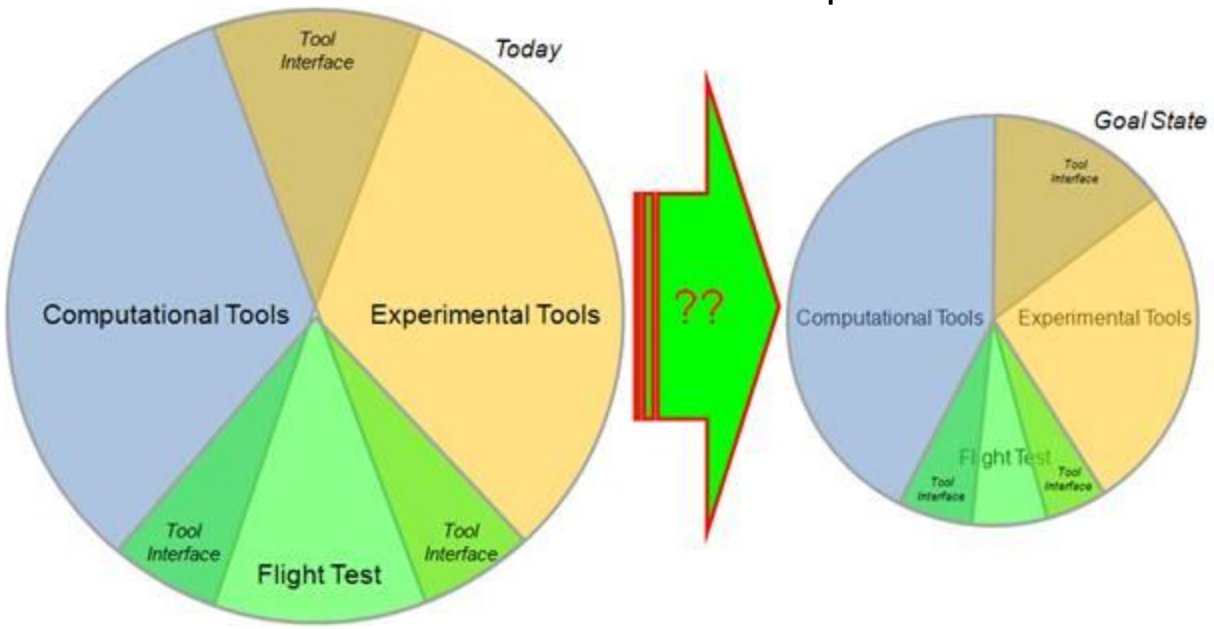
AEDC Facility Usage Trend



Wind Tunnel Users Working Group – US Industry

Mark Melanson email, 8-7-2009

Ultimate Goal is to have an assessment of what industry would consider the "critical" list of test facilities/capabilities



- Faster development cycles (reduced cycle time)
- Higher fidelity (lower risk) designs (better data)
- Lower cost design cycles (reduced expense of necessary data)

- Less reliance on flight and ground testing - More reliance on computational simulation (modeling)
- Highly synergistic and integrated boundaries between data sources
- All sources of design data are of the highest possible quality

Solution Space

- Raise customer rates
- Attract more customers
- Different operations scenarios (block operations)
- Move maintenance, capability improvement and test test technology funds to operations

- Close/mothball facilities
- Increase NASA funding

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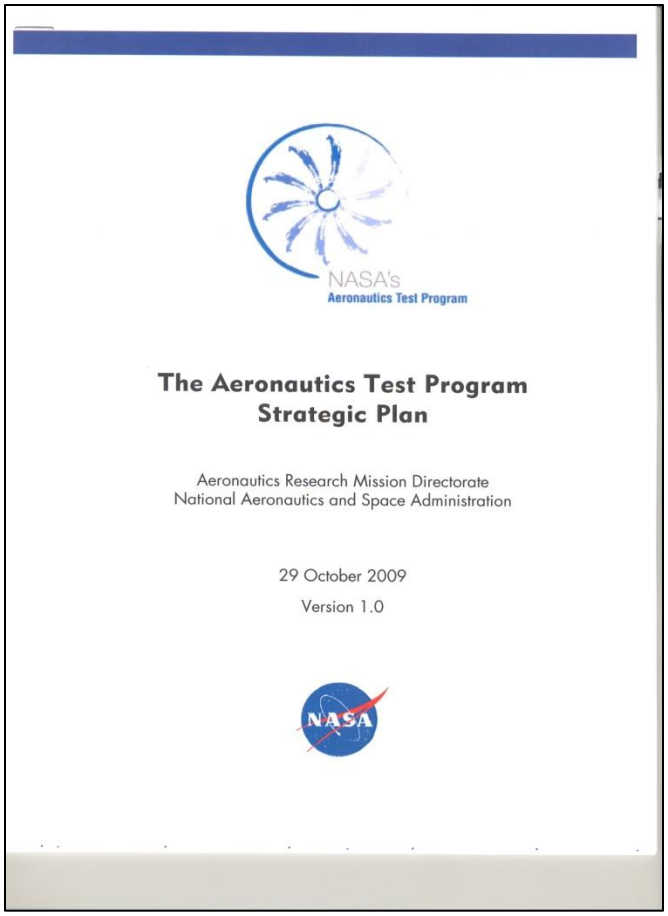
ATP Strategic Plan


NASA's
Aeronautics Test Program

The Aeronautics Test Program
Strategic Plan

Aeronautics Research Mission Directorate
National Aeronautics and Space Administration

29 October 2009
Version 1.0

NASA


Pre-Decisional: For NASA Internal Use Only ***Working Draft***

NASA's
Aeronautics Test Program

NASA

The Aeronautics Test Program
Strategic Implementation Plan

Aeronautics Research Mission Directorate
National Aeronautics and Space Administration

7 October 2009

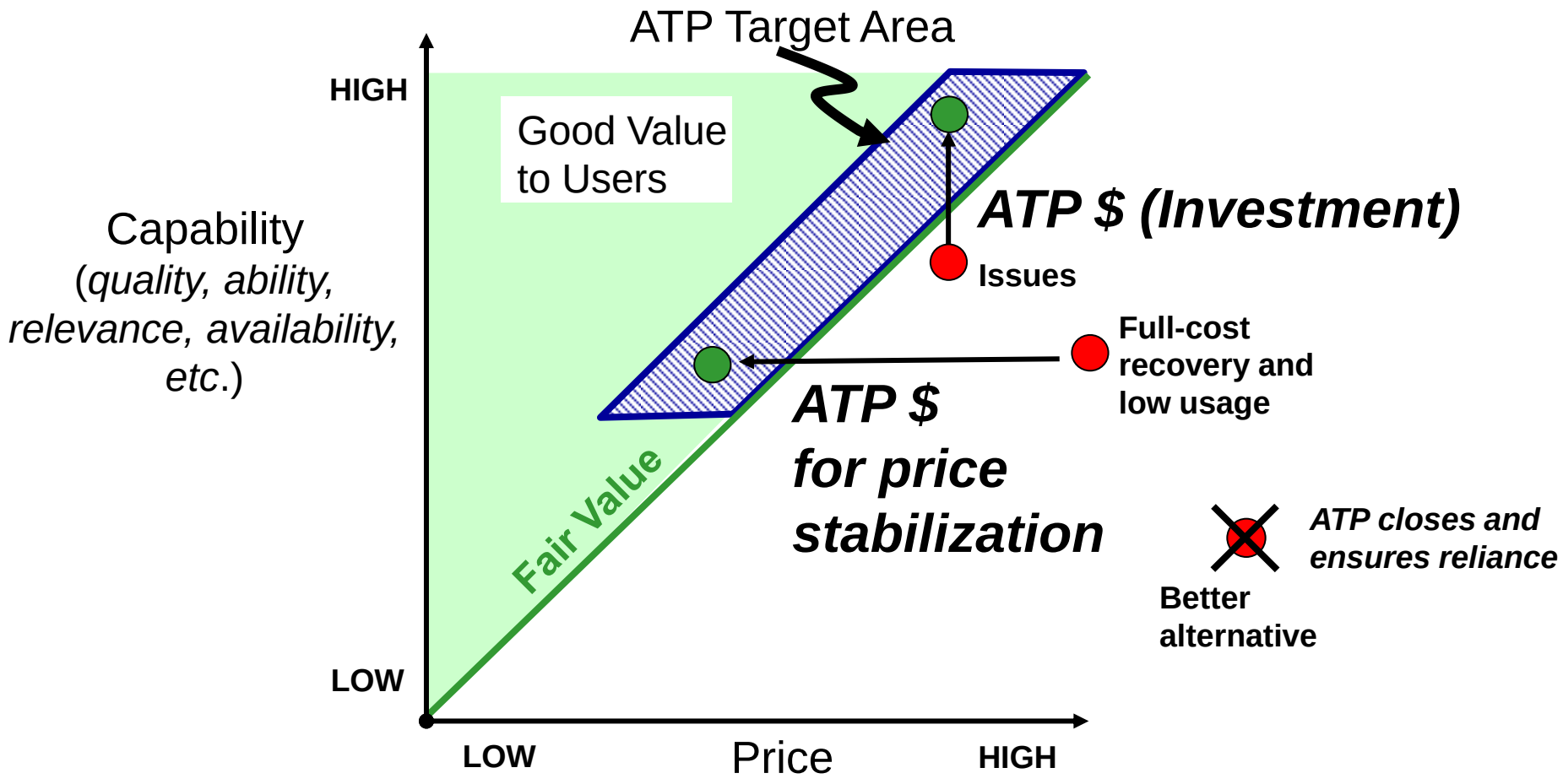
v. 0.8.1

Pre-Decisional: For NASA Internal Use Only ***Working Draft***

Principles Guiding the ATP Strategic Direction

- **National stewardship**. ATP is committed to ensuring healthy and available aeronautics test capabilities not just for NASA but for the nation.
- **Availability, not necessarily ownership**. NASA does not have to own and operate all test facilities needed, but ATP will ensure it can access them through strategic partnerships.
- **Relevance.** Capabilities must evolve to meet future test requirements.
- **"The Big Stuff."** ATP will focus on national-class test capabilities, rather than the quantity or breadth of smaller laboratory facilities.
- **Value.** Reliable facilities and efficient processes will help customers get the most benefit from testing.
- **Public good.** NASA has a role in providing test capabilities that are not economically viable as independent business and thus not available elsewhere.
- **R&D and T&E.** A test facility can support both R&D as well as test and evaluation (T&E) activities.

ATP Goal


ATP Target Area
HIGH
Good Value to Users
Capability (*quality, ability, relevance, availability, etc.*)
ATP $ (Investment)
Issues
Full-cost recovery and low usage
ATP $ for price stabilization
Fair Value
ATP closes and ensures reliance
Better alternative
LOW
LOW
Price
HIGH

Capability Reliance Framework

- **Frames a top-level view of test capabilities to:**
  - **Transparently explain the nation's testing posture**
  - **Facilitate decisions regarding:**
    - **Life-cycle cost status**
    - **Long-term investments**
      - **Sustainment; improvements; gap filling**
    - **Redundancies and associated reliance opportunities**
- **Integrates key information in one place for each test category**
  - **Near- and far-term needs (volume and criticality)**
  - **Global capabilities**
    - **Life-cycle cost profiles**
    - **Maintenance needs**
  - **Alternative capabilities**
    - **Total costs and savings from reliance**
    - **Limitations**

Notional Capability Reliance Framework

Notional values

Facilities

Limitations

Type

Annual Cost

Upgrade Cost

Criticality

Primary/Secondary Capability

			U.S. Government						U.S. Industry					Foreign						
		Current Facilities	NASA				DoD		Veridian	Allied Aerospace				ARA	BAE	DNW	ETW	Onera	STARCS	NRC/IAR
			Ames	Langley		Glenn	AEDC		Calspan						Wharton	NLR	Cologne		Bromma	
			11-Foot	NTF (8x8 ft)	TDT (16x16 ft)	8x6-Foot	16T	4T	8-Foot	7-Foot Trisonic				9x8 ft TWT	HSWT 4-Foot	~6ft HST	~6x8-Foot	~6ft S2MA	~5ft T1500	~5ft trisonic
		Limitations		*productiv., model dynamics, Mach 1.2*		*force*			*Mach 1.4*	*blowdown*	*Mach 1.1*	*blowdown*	*blowdown*	*Mach 1.4*	*blowdown*	*security*	*security*	*security, Mach 1.4*	*security, Mach 1.2*	*blowdown*
		Recent Annual UOH	2,000	1,400																
		Avg Cost/UOH	$4,000	$3,720																
		Power-Consumables Cost/UOH Pressure																		
		Air-On Cost/UOH Atmospheric																		
	Annual Restore (total)	Annual ($)					$12.5M													
		1–5 years	$28.1M	$12.4M	$6.75M	$8.2M	$50.6M													
		6–10 years					$17.4M													
		10–20 years																		
Capability	Criticality and Annual UOH: Near-Term (1-2 years)		Mid-Term (3-7 years)		Long-Term (8+ years)		Additional Costs *(footnotes in italics)*													
Large, high Rn	H	3500	H	3200	H	3000	Testing	*1, 2*		*2*		*1, 2*		*2*		*2*						
							Upgrades	*3*			*3*											
Medium, high Rn	M	1000	M	800	M	600	Testing		*1, 2*		*2*			*2*	*2*	*2*			*2*		*1, 2*	*2*		
							Upgrades		*3*		*3*												
Small high Rn	H	1500	H	1500	H	1500	Testing				*2*		*1*	*2*	*2*	*2*	*2*	*2*	*2*			*2*	*2*	*8*
							Upgrades				*3*							*2*					*7*	
Large, atmospheric	H	2300	H	2000	H	1800	Testing	*1*		*3*														
							Upgrades	*3*																
Medium, atmospheric	M	500	M	500	M	500	Testing		*1*									*2*	*5*	*2*				
							Upgrades		*3*															
Small atmospheric	M	500	M	500	M	500	Testing												*5*		*7*	*8*		
							Upgrades																	
Very hign Rn	H	1000	H	800	H	600	Testing	*2*	*1, 2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*1, 2*	*2*	*2*	*8*
							Upgrades	*3*	*3*	*3*														
Propulsion simulation	H	1500	H	1500	H	1500	Testing	*2*	*2*	*2*	*1, 2*	*1, 2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*6*	*2*	*2*	*2*	*8*
							Upgrades	*3*	*3*	*3*								*9*	*10*			*11*		
Store separation	H	1000	H	1000	H	1000	Testing	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*7*	*8*
							Upgrades	*3*	*3*	*3*								*9*				*11*		
Dynamics/flutter	H	2300	H	2000	H	1800	Testing	*2*	*2*	*1, 2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*8*
							Upgrades	*3*	*3*									*9*				*11*		
Total Annual UOH		14,300		13,100		12,200														

Sizes: Large: 10ft and up
Medium: 6ft - 10ft
Small: 4ft - 6ft

Notes:
1 Includes supersonic 9x7 test cell and loop
2 Includes 4T
3 16T only

Legend:

gray	not capable
white	primary
yellow	secondary
pink	TBD

Note that sources conflict on capabilities in some cases.

Notes:
Sources:

1 RAND TR-134 (2004), Table 2.8
2 RAND TR-134 (2004), Table 4.1
3 "NASA's Aeronautics Test Program" flyers, M-1870 (Nov 2007)
4 RAND TR-134 (2004), Table C.2
5 http://www.etw.de/overview.html
6 http://www.dnw.aero/windtunnels.aspx?id=260&menuid=34&subid=260
7 http://www.starcs.se/t1500.aspx
8 http://wwwreno.nrc-cnrc.gc.ca/obj/iar-ira/doc/wind-tunnel2.pdf
9 http://www.lockheedmartin.com/products/HighSpeedWindTunnel/index.html
10 http://www.baesystems.com/BAEProd/groups/public/documents/ss_asset/bae_pdf_mas_12mwindtunnel.pdf
11 http://www.onera.fr/gmt-en/wind-tunnels/s2ma.php

Large Amount of Data Exists to Populate Framework

- **NPAT (NASA & DoD)**
  - Transonic Assessment (10/2007)
  - Supersonic Assessment (12/2008)
  - Hypersonic Assessment (initiated)
  - Subsonic Assessment (last on list)
- **NASA/ATP**
  - Health Assessment of ATP Facilities (2/2009)
  - NASA Exploration Requirements for Institutional Capabilities (ERIC – 2/2009)
  - NASA Facilities Study (3/2009)
- **RAND**
  - An Update of the Nation's Long-Term Strategic Needs for NASA's Aeronautics Test Facilities (~6/2010)
- **TRMC/IDA**
  - NASA Facilities Critical to DoD (3/2007)
- **Wind Tunnel Users Working Group – US Industry**
  - Infrastructure Recommendations for Implementation of Executive Order 13419
  - National Aeronautics Research and Development (1/2008)
  - Assessment of Supersonic Wind Tunnel Capability (12/2008)
- **OSTP/ASTS (IIWG)**
  - National Aeronautics RDT&E Infrastructure Plan (~9/2009)

Capability Reliance Framework
A Step Toward a National Approach

- ATP's (NASA's) Challenge
  - Usage of ATP facilities has gone down considerably over the last decade
    - Many of ATP facilities are operating at a fraction of one-shift capacity
  - Demand for new capabilities (instrumentation, data quality, test technology, etc.) is increasing
  - A large % of ATP infrastructure is 50+ years in age
  - ATP's budget is flat lined

- ATP's challenge is similarly reflected in the DoD world, and the while wind tunnels will remain important in the future, their role is changing

- The Capability Reliance Framework would provide the foundation and direction to a National solution to the problem
  - National solution generates challenges
    - Increased reliance/dependence across agencies
    - Requirement to invest across agencies

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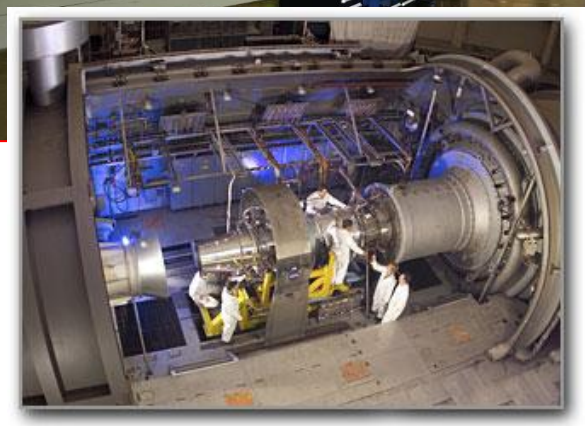
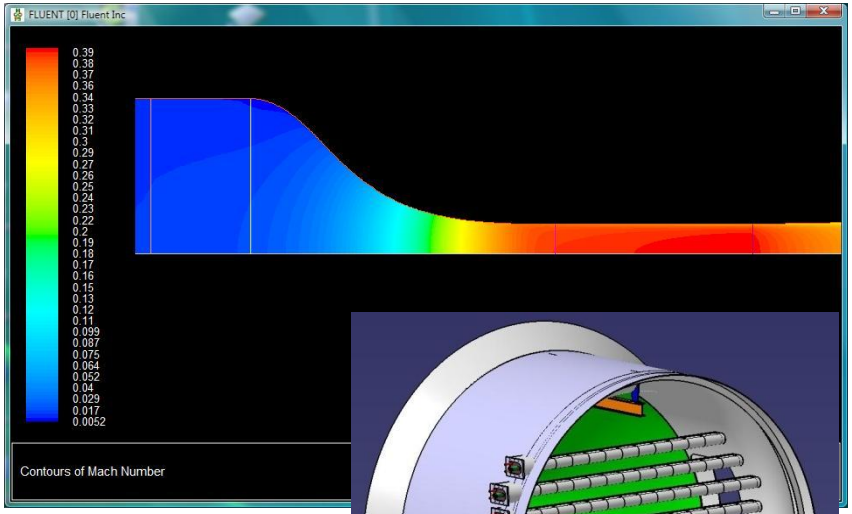
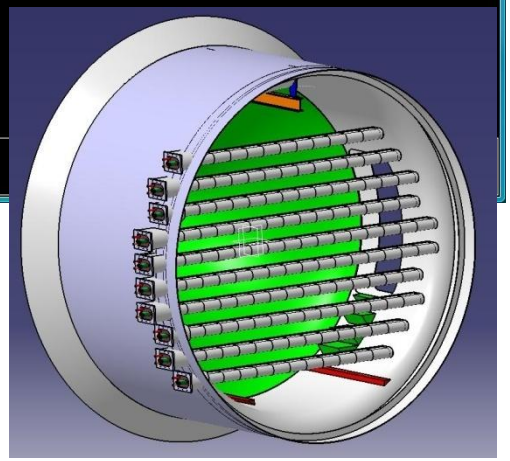
High-Altitude Ice Crystal Capability at GRC PSL ($4.8M)

- **Ice Crystal Capability at the Propulsion Systems Laboratory Glenn Research Center**
  - Simulate high-altitude icing for research, mitigation approaches and certification
  - Important capability for Aviation Safety Program
  - Initial design completed, final design and prototype hardware is underway



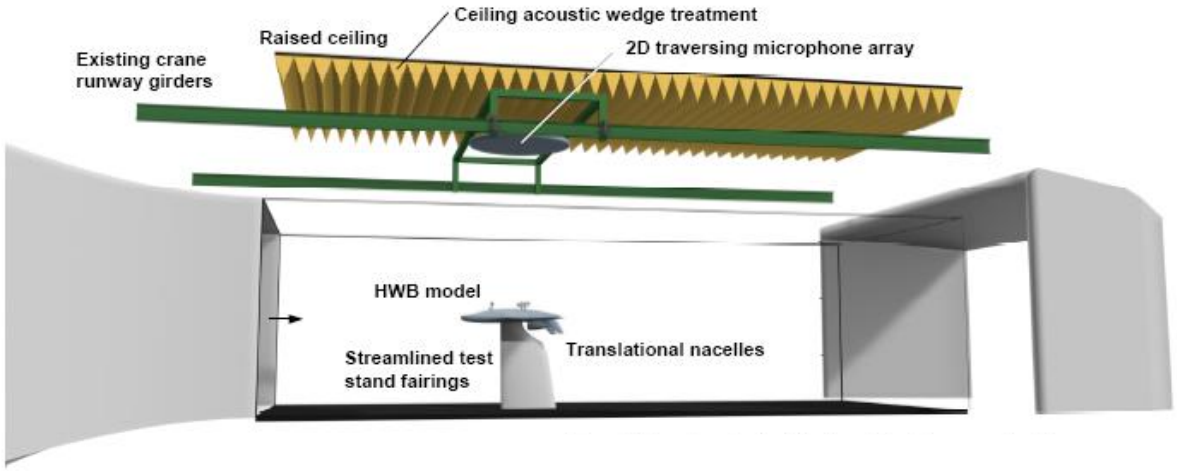


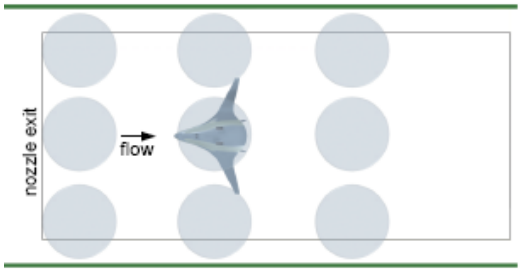


Acoustic Upgrades to LaRC 14x22 ($5M)

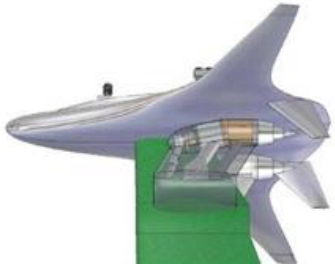
The HWB Acoustic Test

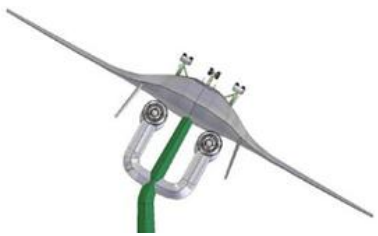
- New acoustic measurement capability
- New hot jet simulator testing capability
- Detailed noise mapping of advanced vehicle design

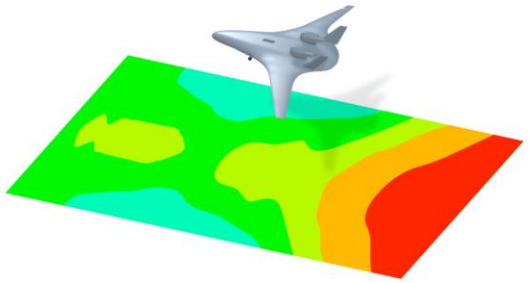




Top view with some array positions



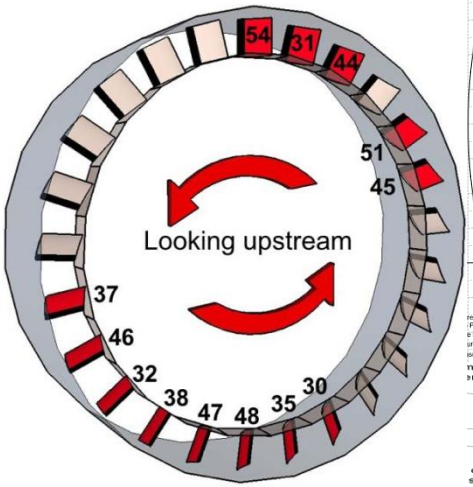


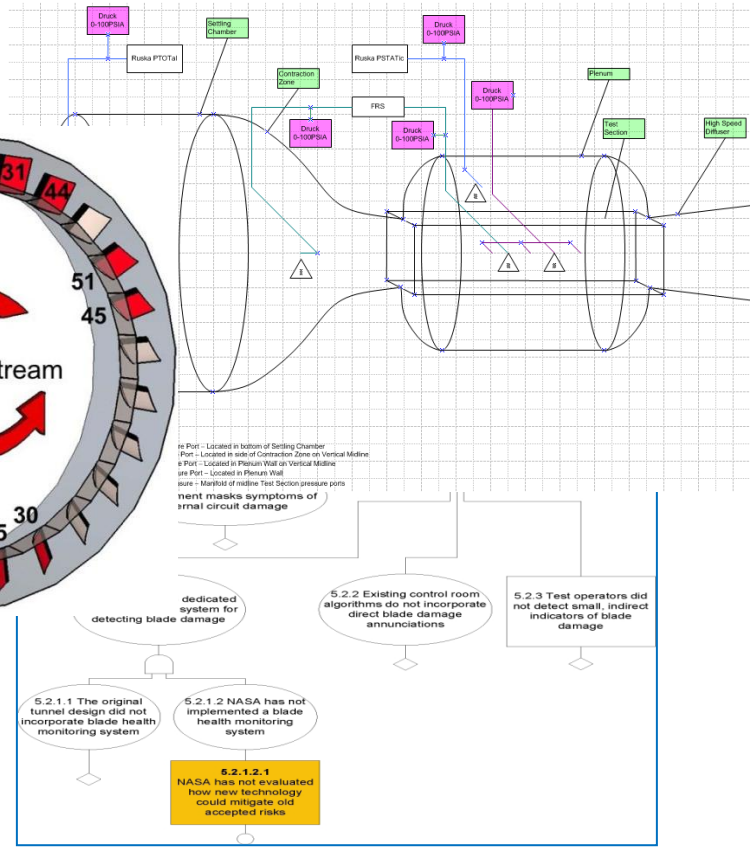


Sting-mounted, translating Jet Engine Simulators

NTF Data Quality, Productivity & Reliability Improvements ($9M)

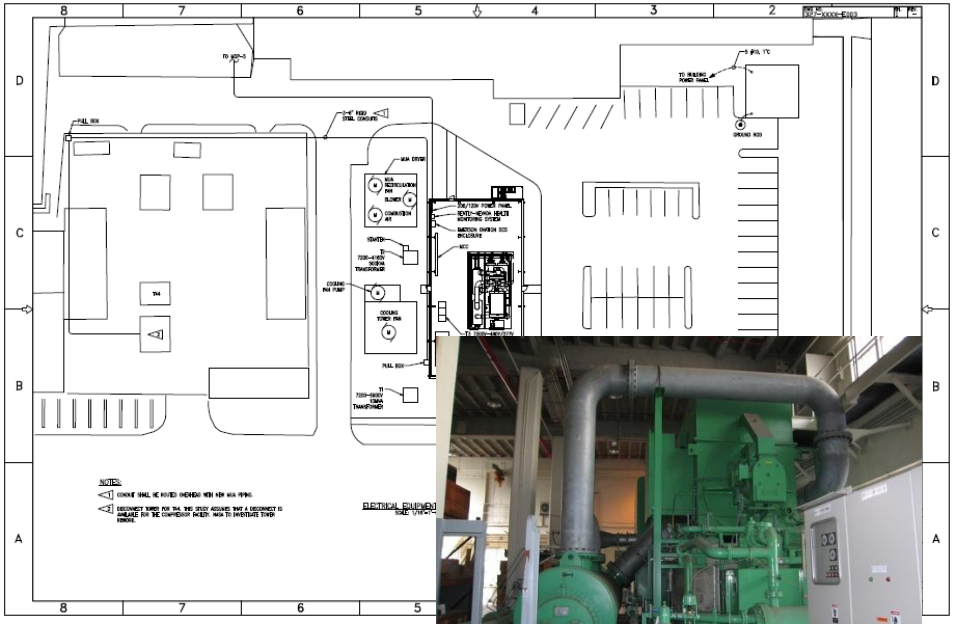
- **National Transonic Facility Improvements Langley Research Center**
  - Data Repeatability Improvements
  - Mishap Board Recommendations
  - Reliability and Productivity Improvements





Air Compressor Capability and Reliability Improvements at ARC UPWT ($9M)

- **Reliability Improvements for the Unitary Plan Wind Tunnel Air Compression System, Ames Research Center**
  - Relocate/connect unused, existing 50,000 cfm, 11.2 MW compressor
  - Eliminate single point failure of obsolete compressor
  - Improve tunnel productivity with both machines are online



New Refrigeration and Heat Exchanger at GRC IRT ($18.8M)

- **New Refrigeration System for the Icing Research Tunnel Glenn Research Center**
  - Performance of existing system has degraded over 65 years of operation
  - Refrigerant fluid has been changed, multiple leaks exist (5,000 lbs/yr)
  - Must be kept online to prevent expansion and loss of gas
  - New tunnel heat exchanger is required to provide full capability

Upside and Downside to ARRA Projects

- Upside
  - ARRA Projects providing an influx of $46.6M to new facility capability and reliability projects
- Downside
  - Integrated System Testing (IST) and calibration will not be part of ARRA projects and become a liability for ATP and Research Programs
  - Targeted facilities will be off-line due to projects resulting in loss of customer income

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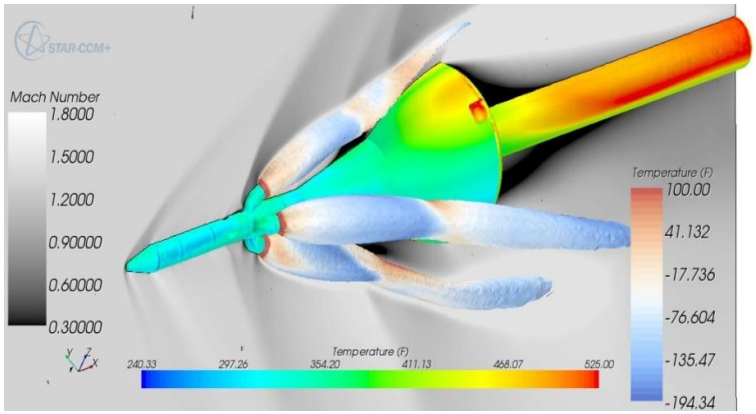
Ames UPWT
CEV 80-AS Hot Helium Test

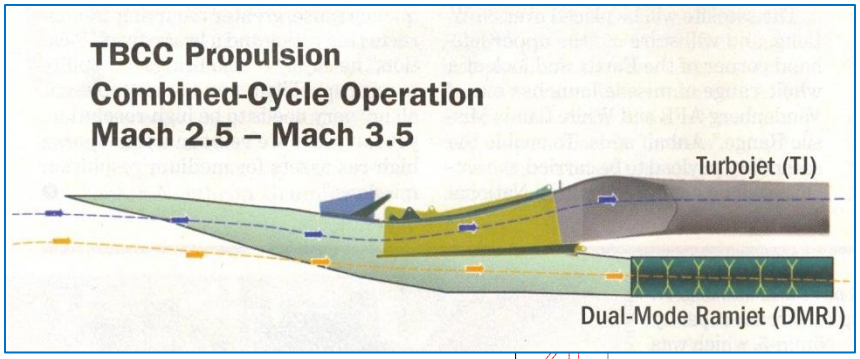
- CEV Launch Abort Aeroacoustic Test (CEV 80-AS) to define external acoustic environments for abort scenarios
  - **Tests will be performed in both 11'X11' and 9'X7' test sections of the Unitary Plan Wind Tunnel**
  - **Helium as the simulant gas for the abort motor plumes**
  - **Scheduled for Summer 2010**
- Requirements
  - **Helium gas delivered to the model during test at 700° F and 600 PSI flowing at 5.2 lbm/sec**



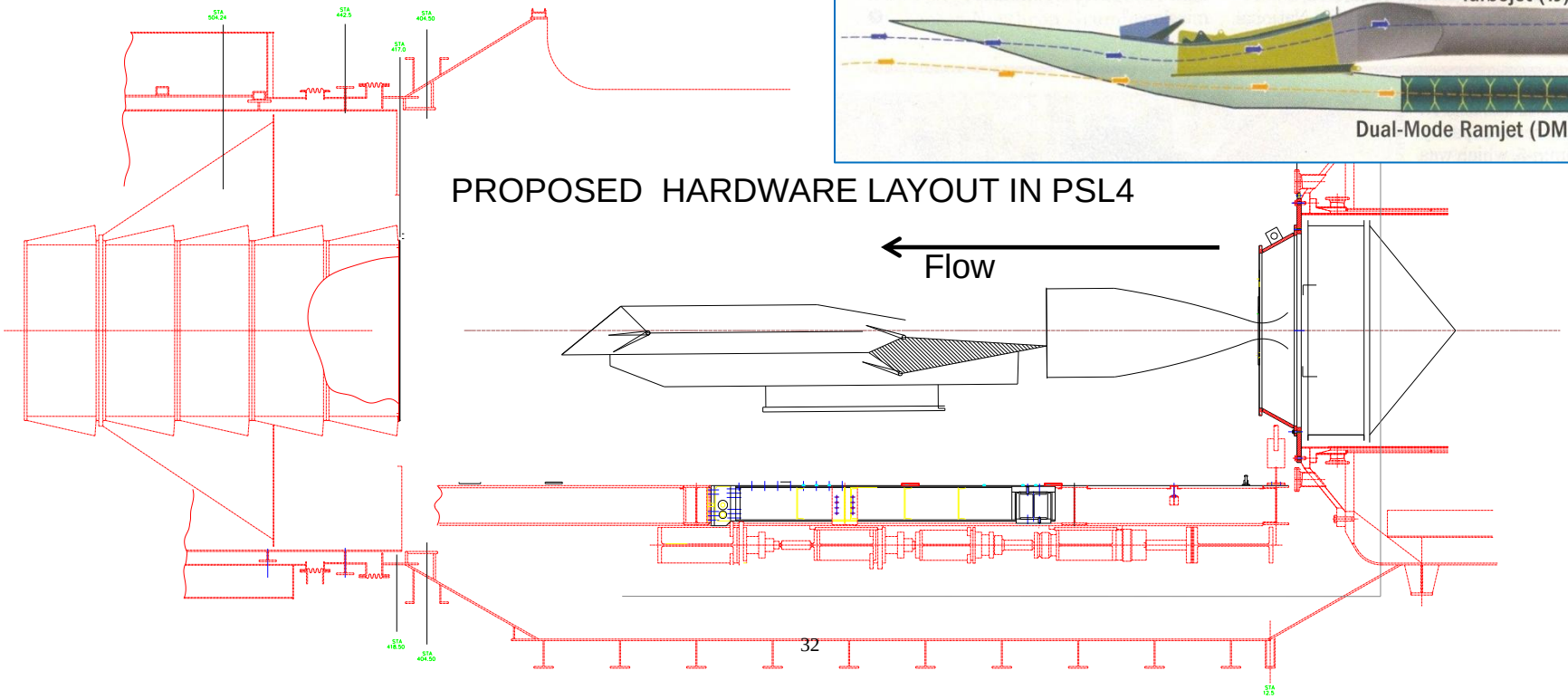
Mode Transition (MoTr) Demonstration Program

- Validate the ability of an integrated hydrocarbon fueled, Turbine Base Combined Cycle (TBCC) engine to transition form turbojet to ramjet mode during ground testing

DARPA/NASA GRC



PROPOSED HARDWARE LAYOUT IN PSL4

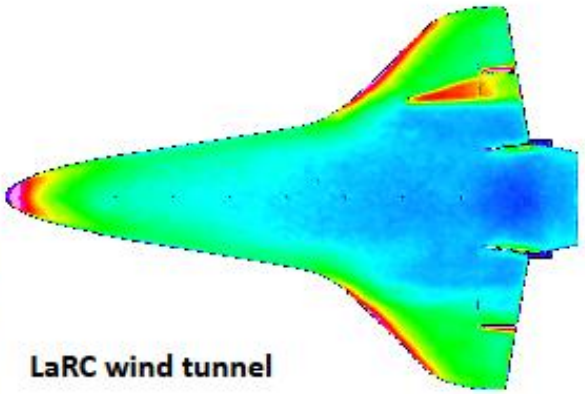


HYTHIRM

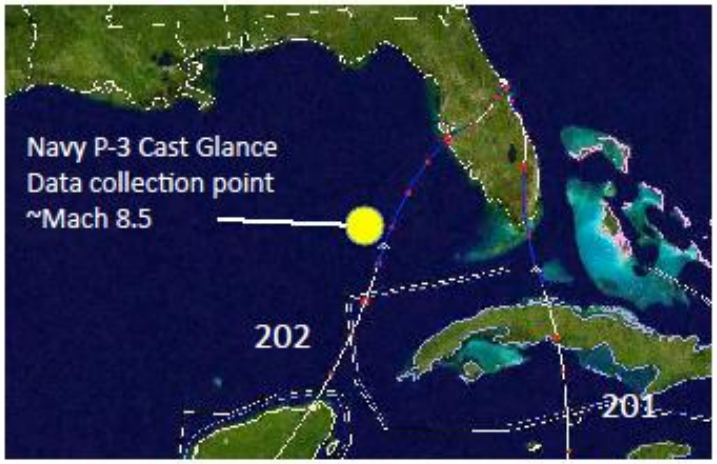
HYTHIRM

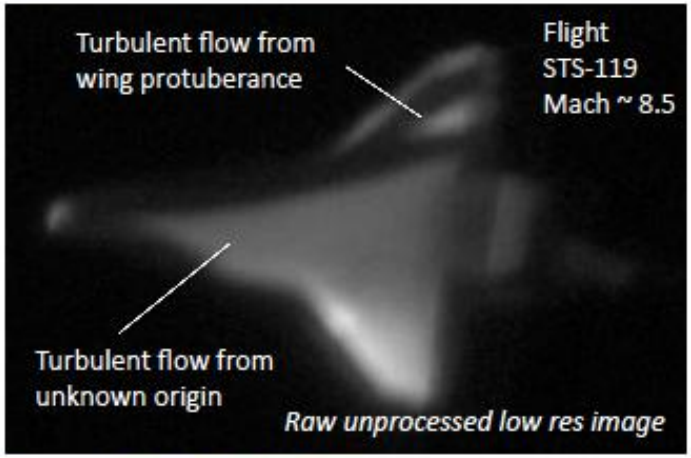
Hypersonic Thermodynamic Infrared Measurements

STS-119 success criteria: To obtain spatially resolved infrared imagery that will provide a quantified surface temperature map of the Shuttle during hypersonic re-entry



LaRC wind tunnel





POC's: Thomas.J.Horvath@nasa.gov (PI) and Paul.W.Krasa@nasa.gov (PM)
Sponsors: NASA JSC SSPO

Outline of Presentation

- Program Overview
- Changing Test Environment and Challenge
- ATP Strategic Plan and Reliance Initiative
- American Recovery and Reinvestment Projects
- Upcoming Tests
- Partnerships

Partnerships

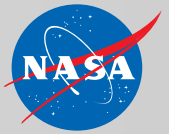
- National Partnership for Aeronautical Testing (NPAT)
- Infrastructure Interagency Working Group (IIWG)
- Wind Tunnel Users Working Group – US Industry

Improve National Coordination and Cooperation

National Partnership for Aeronautical Testing (NPAT)

Expand cooperation between NASA and DoD and facilitate the establishment of an integrated national strategy for the management of their respective aeronautical test facilities

NPAT Council Membership



Dr. Jaiwon Shin
Associate Administrator, Aeronautics Research Mission Directorate (NASA Co-Chair)

- **Thomas Irvine**
  Deputy Associate Administrator, Aeronautics Research Mission Directorate
- **Jay Dryer**
  Director, Fundamental Aeronautics Program
- **Michael George**
  Director, Aeronautics Test Program
- **Frank Bellinger**, ***Director, Facilities and Engineering and Real Property***

Dr. John Foulkes
Director, Test Resource Management Center (DoD Co-Chair)

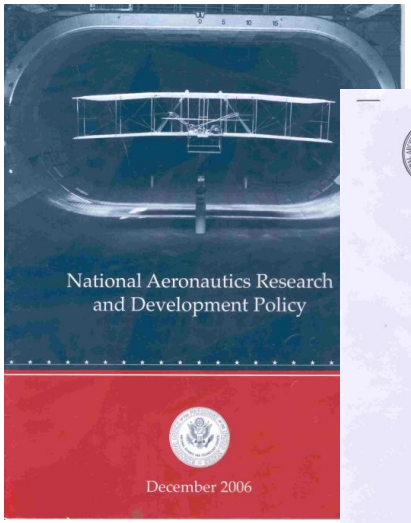
- **Dr. Spiro Lekoudis**
  Director, Defense Research and Engineering
- **Dr. Thomas Killion**
  Chief Scientist, Department of the Army
- **Richard Gilpin***
  Director, Air Vehicle Department, Naval Air Systems Command
- **Ricky Peters**
  Deputy Director, Test and Evaluation, HQ US Air Force

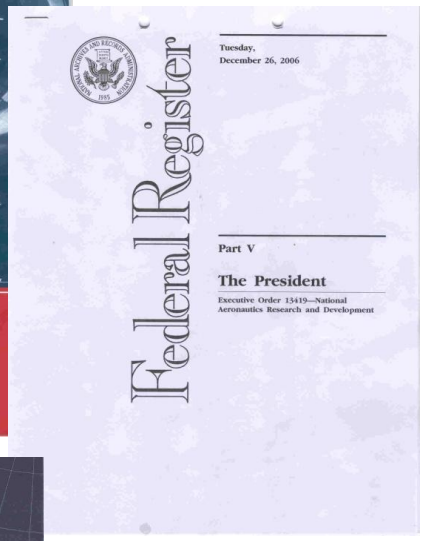
* **Acting, pending a replacement from the Office of the Secretary of the Navy**

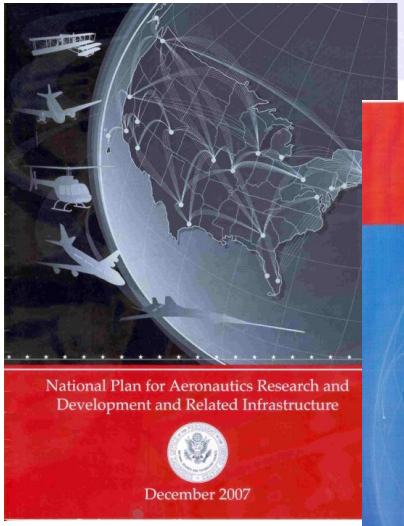
NPAT Activities

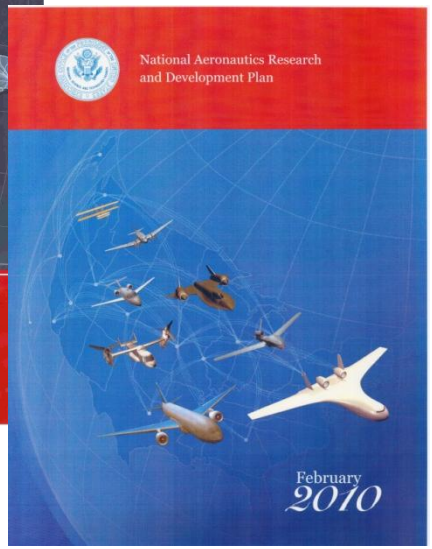
- Access and Pricing Guiding Principles (signed 7/22/2008)
- Facility Assessments
  - Transonic (11/2007, AEDC-TR-07-12)
  - Supersonic (8/2009, AEDC-TR-09-F-3)
  - Hypersonic (underway)
  - Subsonic
- Resolution of NASA 30’x60’ Closure/Demolition
- DoD/NASA Aeronautics Test Facility Users’ Meeting
  - 9/14/2005, 3/28/2007, 9/25/2008, 4/8/2010
- Establishment of joint DoD/NASA test technology efforts
- Capability Reliance Framework
- Oversight of DoD/NASA activities, National Force Measurement Technology Team, AEDC/NASA Hypersonic Integrated Propulsion Test Team, common model, +++

Plan for Federal Aeronautics RDT&E Infrastructure









- 12/20/2006 OSTP issues National Aeronautics R&D Policy
- 12/26/2006 Executive Order 13419 – President ➔ Director OSTP ➔ submit a plan for national aeronautics R&D and related infrastructure in one year
- 12/2007 National Plan for Aeronautics Research and Development and Related Infrastructure ➔ calls for development of a plan for aeronautics RDT&E infrastructure
- 7/15/2008 Infrastructure Interagency Working Group (IIWG) chartered and tasked with defining the infrastructure requirements to enable the achievement of the national aeronautics goals and objectives
- 10/08/2009 Draft National Infrastructure Plan
- 2/2010 Updated National Aeronautics R&D Plan
- Realignment of Draft National Infrastructure Plan with 2010 R&D Plan

IIWG Membership

IIWG Co-Chairs

Michael George, Director, Aeronautics Test Program, NASA
Sheila Wright, Senior Policy Analyst, Test Resources Management Center
Shelley Yak, Manager of Operations, William J. Hughes Technical Center, FAA

IIWG Executive Secretary

Scott Doucett, Project Engineer, Target Generation Facility, William J. Hughes Tech. Center, FAA

IDA Focal Point

Terry Trepal

Task Force Co-Chairs

Ground-Test Facilities

John Thomas Best, Technical Director, Plans and Programs, Arnold Engineering Development Center, USAF

Jeffrey Swan, Deputy Chief, Testing Division, Glenn Research Center, NASA

Simulation Facilities

Michael Madden, Aerospace Engineer, NASA Langley Research Center

Hilda DiMeo, Manager, Integration and Interoperability Facility, FAA William J. Hughes Tech. Center

Flight-Test Facilities

Tom Curtis, Dep. Director, Integrated Systems Evaluation, Experimentation and Test Department, Naval Air Systems Command, Navy

Tony Ginn, Manager, Advanced Planning and Partnerships, NASA Dryden Flight Research Center

High-End Computational Facilities

Dr. Bryan Biegel, Deputy Chief, NASA Advanced Supercomputing Division, NASA Ames Research Center

Dr. Leslie Perkins, Deputy Director, Computational Science and Engineering Office, AFRL, USAF

Cyber Infrastructure

James W. Harris, Director, Test Systems Directorate, NASA Dryden Flight Research Center

George Rumford, Manager, Test and Evaluation/Science and Technology Program, TRMC, DoD

Scott Doucett, Project Engineer, Target Generation Facility, William J. Hughes Technical Center, FAA

Infrastructure Interagency Working Group (IIWG)

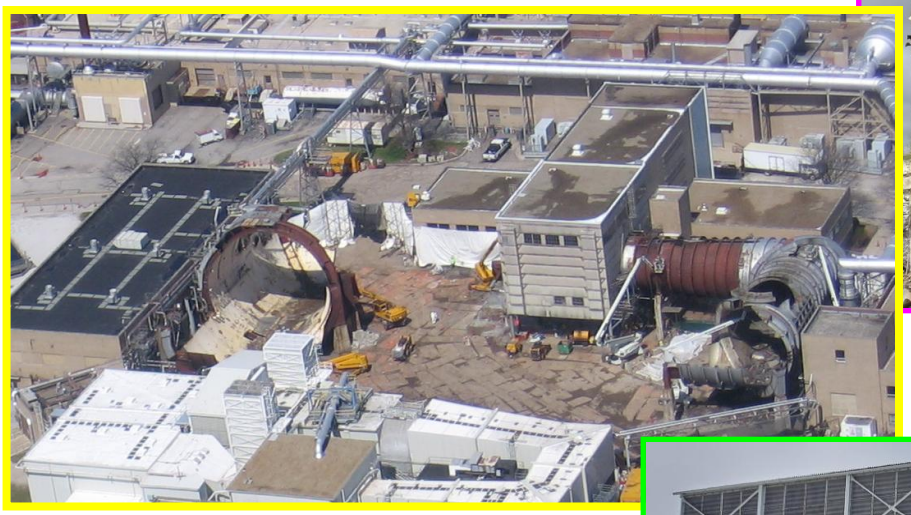
- IIWG objectives
  - Assessment of the infrastructure capabilities required
  - Assessment of the current infrastructure
  - Comparative analysis of the two assessments identifying shortfalls and redundancies
  - Assessment of international dependencies and regulations
  - Recommendations for infrastructure management approaches based on a national perspective

- IIWG Task Forces
  - High-End Computing
  - Flight Test Facilities
  - Ground Test Facilities
  - Simulation Facilities
  - Cyber Infrastructure

Landscape is Changing

ARC 14’ Transonic Tunnel

GRC Altitude Wind Tunnel



LaRC 7’x10’ High-Speed Tunnel